

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
7 June 2001 (07.06.2001)

PCT

(10) International Publication Number
WO 01/40362 A1

(51) International Patent Classification⁷:
B29C 44/34, C08J 9/12 // C08L 25/06

C08J 9/00.

(74) Agents: CHI, Anthony, R. et al.; Owens Corning Science & Technology Center, Building 54-1, 2790 Columbus Road, Granville, OH 43023-1200 (US).

(21) International Application Number: PCT/US00/31148

(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(22) International Filing Date:

14 November 2000 (14.11.2000)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

09/451,618 30 November 1999 (30.11.1999) US

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

(71) Applicant (for all designated States except US): OWENS CORNING [US/US]; One Owens Corning Parkway, Toledo, OH 43659 (US).

Published:

- With international search report.
- Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(72) Inventors; and

(75) Inventors/Applicants (for US only): MILLER, Larry, M. [US/US]; 2070 Swartz Road, Suffield, OH 44260 (US). BREINDEL, Raymond, M. [US/US]; 3878 Edison Street Northeast, Hartville, OH 44632 (US). WEEKLEY, Mitchell, Z. [US/US]; 310 North Elm Avenue, Tallmadge, OH 44278 (US). CISAR, Thomas, E. [US/US]; 824 Falls Avenue, Cuyahoga Falls, OH 44221 (US).

WO 01/40362 A1

(54) Title: EXTRUDED FOAM PRODUCT

(57) Abstract: The present invention is drawn to an extruded polymer foam product with a substantially rounder cell size. The rounder cell size is achieved through the use of both titanium dioxide and talc.

EXTRUDED FOAM PRODUCT

FIELD OF THE INVENTION

5 The present invention generally relates to processes for preparing extruded foam products and more particularly to a process for producing extruded foam products having a substantially round cell size.

BACKGROUND OF THE INVENTION

10 Extruded synthetic resinous foams are useful materials for many applications including thermal insulation, decorative purposes, packaging and the like. In general, extruded foam products may be made by melting a resinous mixture; mixing it thoroughly with a fluid blowing agent or agents under heat and pressure which prevents foaming thereby making a foamable gel; then extruding into a zone of lower pressure to cause 15 foaming and formation of the final extruded foam product.

The shape of the cells within extruded foam products is typically described by an x-axis, y-axis, and z-axis wherein the x-axis is parallel to the extrusion direction, the y-axis (also called the horizontal direction) is perpendicular and shares the same plane as the extrusion direction, the z-axis (also called the vertical direction) is perpendicular to 20 both the x-axis and the y-axis.

Because of the manner in which the blowing agent escapes during the extruded foam manufacturing process, the cells often take an oblong shape in the z-axis, or vertical direction. This oblong shape is undesirable because it makes the final extruded foam product more difficult to machine. The oblong shape also tends to detrimentally increase 25 thermal conductivity in the z-axis due to the oblong shape in that axis. It would therefore be desirable to discover a extruded foam manufacturing process whereby the oblong cell size shape in the z-axis is minimized and rounder shaped cells are produced.

Titanium dioxide or talc has been used as a nucleating agent in the extruded foam manufacturing process. As nucleating agents, titanium dioxide or talc tended to produce 30 smaller cell sizes. Titanium dioxide has also been used as an infrared attenuating agent. However, the use of titanium dioxide alone or talc alone in the extruded foam manufacturing process does not minimize the oblong cell size shape in the z-axis and produce rounder shaped cells.

SUMMARY OF THE INVENTION

According to the present invention, there is a polymer foam comprising a quantity of titanium dioxide and talc in sufficient amounts to minimize the oblong cell size in the z-axis thereby producing rounder cells when compared to that of a corresponding foam without titanium dioxide and talc.

According to the present invention, there is a process for making extruded polymer foam comprising heating a polymer to form a melt polymer material; incorporating titanium dioxide and talc into the melt polymer; incorporating a blowing agent at an elevated pressure to form a foamable gel; cooling the foamable gel to an optimum foaming temperature; and extruding the cooled foamable gel through a die into a region of lower pressure to form a foam. The titanium dioxide and talc are incorporated in an amount sufficient to minimize the oblong cell size in the z-axis thereby producing rounder shaped cells when compared to that of a corresponding foam without titanium dioxide and/or talc.

DETAILED DESCRIPTION OF THE INVENTION

EXTRUDED FOAM MANUFACTURE PROCESS

Surprisingly, it has been found that when titanium dioxide and talc are used together in an extruded foam manufacturing process, there is a reduction in the oblong cell size shape in the z-axis thereby creating rounder shaped cells when compared to that of a corresponding foam without titanium dioxide and/or talc. Although the titanium dioxide and talc of this invention may be incorporated in any process for making extruded foam products to produce rounder cell shapes, the preferred extruded foam manufacture process comprises heating to a first temperature, a resin mixture comprising polymer thereby producing a plastified resin mixture; incorporating one or more fluid blowing agents and thoroughly mixing with the plastified resin mixture under a first pressure and under conditions permitting thorough mixing of the blowing agent into the plastified resin mixture while preventing foaming of the mixture. The mixing in any of the aforementioned steps may be performed by any means known in the art such as with an extruder, mixer, blender, or the like. Once the blowing agent is incorporated and thoroughly mixed with the plastified resin mixture the resulting composition is referred to as a foamable gel. The foamable gel is then cooled to a second temperature (also referred

to as die melt temperature), and is extruded into a zone of reduced pressure (second pressure) resulting in foaming of the gel and formation of the desired extruded foam product.

The first temperature must be sufficient to plastify or melt the polymer. Therefore 5 the first temperature is at or above the glass transition temperature or melting point of the polymer. Preferably the first temperature is from 135°C -240°C (275°F-464°F), more preferably is from 145°C -210°C (293°F-410°F), and most preferably from 150°C-165°C (302°F-329°F). Preferably the second temperature or die melt temperature is cooler than the first temperature. The die melt temperature is preferably from 140-105°C (284°F-10 221°F), more preferably from 130°C -110°C (266°F-230°F), most preferably from about 125°C -115°C (257°F-239°F).

The first pressure must be sufficient to prevent prefoaming of the foamable gel which contains the blowing agent. Prefoaming involves the undesirable premature foaming of the foamable gel before extrusion into a region of reduced pressure. 15 Accordingly, the first pressure varies depending upon the identity and amount of blowing agent in the foamable gel. In one embodiment, the first pressure is from 700-6000 psia (4.826 – 41.36 MPa). In another embodiment, the first pressure is from 840-5000 psia (5.791 – 34.47 MPa). In a preferred embodiment, the first pressure is from 1150-4500 psia (7.928 – 31.02 MPa).

20 The second pressure is sufficient to induce conversion of the foamable gel into a foam body. In one embodiment, the second pressure is from 0-28 psia (0 – 193 kPa). In another embodiment, the second pressure is from 1.4-21 psia (9.652 – 144.7 kPa). In a preferred embodiment, the second pressure is from about 2.8-15 psia (19.30 - 103.4 kPa).

25 POLYMER

Any polymer capable of being foamed may be used as the polymer in the resin mixture. The polymer may be thermoplastic or thermoset. Suitable plastics include polyolefins, polyvinylchloride, alkenyl aromatic polymers, polycarbonates, polyetherimides, polyamides, polyesters, polyvinylidene chloride, 30 polymethylmethacrylate, polyurethanes, polyisocyanurates, phenolics, copolymers and terpolymers of the foregoing, thermoplastic polymer blends, rubber modified polymers, and the like. Suitable polyolefins include polyethylene and polypropylene, and ethylene copolymers.

A preferred thermoplastic polymer comprises an alkenyl aromatic polymer material. Suitable alkenyl aromatic polymer materials include alkenyl aromatic homopolymers and copolymers of alkenyl aromatic compounds and copolymerizable ethylenically unsaturated comonomers. The alkenyl aromatic polymer material may 5 further include minor proportions of non-alkenyl aromatic polymers. The alkenyl aromatic polymer material may be comprised solely of one or more alkenyl aromatic homopolymers, one or more alkenyl aromatic copolymers, a blend of one or more of each of alkenyl aromatic homopolymers and copolymers, or blends of any of the foregoing with a non-alkenyl aromatic polymer. Regardless of composition, the alkenyl aromatic 10 polymer material comprises greater than 50 and preferably greater than 70 weight percent alkenyl aromatic monomeric units. Most preferably, the alkenyl aromatic polymer material is comprised entirely of alkenyl aromatic monomeric units.

Suitable alkenyl aromatic polymers include those derived from alkenyl aromatic compounds such as styrene, alphamethylstyrene, ethylstyrene, vinyl benzene, vinyl 15 toluene, chlorostyrene, and bromostyrene. A preferred alkenyl aromatic polymer is polystyrene. Minor amounts of monoethylenically unsaturated compounds such as C._{sub}2-6 alkyl acids and esters, ionomeric derivatives, and C._{sub}4-6 dienes may be copolymerized with alkenyl aromatic compounds. Examples of copolymerizable compounds include acrylic acid, methacrylic acid, ethacrylic acid, maleic acid, itaconic 20 acid, acrylonitrile, maleic anhydride, methyl acrylate, ethyl acrylate, isobutyl acrylate, n-butyl acrylate, methyl methacrylate, vinyl acetate and butadiene. Preferred structures comprise substantially (that is, greater than 95 percent) and most preferably entirely of polystyrene.

The properties of the extruded foam product can be modified by selection of the 25 molecular weight of the polymer. For example, the preparation of lower density extruded foam products is facilitated by using lower molecular weight polymers whereas the preparation of higher density extruded foam products is facilitated by the use of higher molecular weight or higher viscosity resins.

30 TITANIUM DIOXIDE AND TALC

Titanium dioxide and talc are incorporated in to the extruded foam product in amounts sufficient to minimize the oblong cell size in the z-axis thereby producing rounder shaped cells when compared to that of a corresponding foam without the titanium

dioxide and/or talc. A corresponding foam is a foam of a similar polymer material composition and density. Typically, titanium dioxide is present from 0.1 to 5.0 wt %, preferably 0.2 to 4.0 wt %, and most preferably from 0.5 to 2.5 wt % of the polymer. Typically, talc is present from 0.1 to 5.0 wt %, preferably 0.2 to 4.0 wt %, and most 5 preferably from 0.5 to 2.5 wt % of the polymer.

OPTIONAL ADDITIVES

Optional additives which may be incorporated in the extruded foam product include infrared attenuating agents, plasticizers, flame retardant chemicals, pigments, 10 elastomers, extrusion aids, antioxidants, fillers, antistatic agents, UV absorbers, etc. These optional additives may be included in any amount to obtain desired characteristics of the foamable gel or resultant extruded foam products. Preferably, optional additives are added to the resin mixture but may be added in alternative ways to the extruded foam manufacture process. For example, optional additives may be incorporated before, during 15 or after the polymerization process used to make the polymer in the resin mixture.

Plasticizers may also be added in the extruded foam manufacture process, preferably added to the foamable gel to facilitate processing of the foamable gel in an extruder. In a preferred embodiment, the plasticizer is a low molecular weight resin (molecular weight below about 20,000). Examples of plasticizers include liquid paraffin, 20 or white oil, hydrogenated coconut oil, esters of C₄-C₂₀ monoalcohols, diols glycerine with higher fatty acids, styrene resin, vinyl toluene resin, alpha-methylstyrene resin, lower alcohols (containing 1 to about 4 carbon atoms), etc. In one embodiment, from about 0.1 to about 20 parts of plasticizer per 100 parts of the polymer is incorporated into the foamable gel. In a preferred embodiment, from about 1 to about 15 parts of plasticizer 25 per 100 parts of the polymer are incorporated into the foamable gel.

Flame-retardant chemicals may also be added in the extruded foam manufacture process, preferably added to the foamable gel to impart flame retardant characteristics to the resulting extruded foam products. Flame-retardant chemicals include brominated aliphatic compounds such as hexabromocyclododecane and pentabromocyclohexane, 30 brominated phenyl ethers, esters of tetrabromophthalic acid, and combinations thereof. In one embodiment, from about 0.1 to about 5 parts of flame-retardant chemicals per 100 parts of the polymer is incorporated into the foamable gel. In a preferred embodiment,

from about 0.5 to about 3 parts of flame-retardant chemicals per 100 parts of the polymer are incorporated into the foamable gel.

BLOWING AGENTS

5 Any suitable blowing agent may be used in the practice on this invention. Blowing agents useful in the practice of this invention include inorganic agents, organic blowing agents and chemical blowing agents. Suitable inorganic blowing agents include carbon dioxide, nitrogen, argon, water, air, nitrogen, and helium. Organic blowing agents include aliphatic hydrocarbons having 1-9 carbon atoms, aliphatic alcohols having 1-3 carbon atoms, and fully and partially halogenated aliphatic hydrocarbons having 1-4 carbon atoms. Aliphatic hydrocarbons include methane, ethane, propane, n-butane, isobutane, n-pentane, isopentane, and neopentane. Aliphatic alcohols include, methanol, ethanol, n-propanol, and isopropanol. Fully and partially halogenated aliphatic hydrocarbons include fluorocarbons, chlorocarbons, and chlorofluorocarbons. Examples of fluorocarbons include methyl fluoride, perfluoromethane, ethyl fluoride, 1,1-difluoroethane (HFC-152a), 1,1,1-trifluoroethane (HFC-143a), 1,1,1,2-tetrafluoro-ethane (HFC-134a), pentafluoroethane, difluoromethane, perfluoroethane, 2,2-difluoropropane, 1,1,1-trifluoropropane, perfluoropropane, dichloropropane, difluoropropane, perfluorobutane, and perfluorocyclobutane. Partially halogenated chlorocarbons and chlorofluorocarbons for use in this invention include methyl chloride, methylene chloride, ethyl chloride, 1,1,1-trichloroethane, 1,1-dichloro-1-fluoroethane (HCFC-141b), 1-chloro-1,1-difluoroethane (HCFC-142b), chlorodifluoromethane (HCFC-22), 1,1-dichloro-2,2,2-trifluoroethane (HCFC-123) and 1-chloro-1,2,2,2-tetrafluoroethane (HCFC-124), and the like. Fully halogenated chlorofluorocarbons include trichloromonofluoromethane (CFC-11), dichlorodifluoromethane (CFC-12), trichlorotrifluoroethane (CFC-113), 1,1,1-trifluoroethane, pentafluoroethane, dichlorotetrafluoroethane (CFC-114), chloroheptafluoropropane, and dichlorohexafluoropropane. Chemical blowing agents include azodicarbonamide, azodiisobutyro-nitrile, benzenesulfonhydrazide, 4,4-oxybenzene sulfonyl-semicarbazide, p-toluene sulfonyl semi-carbazide, barium azodicarboxylate, and N,N'-dimethyl-N,N'-dinitrosoterephthalamide and trihydrazino triazine.

This invention is particularly useful for extruded foam manufacturing processes which employ blowing agents having a high volatility or high foaming rate. Such

blowing agents tend to produce oblong shaped cells along the z-axis. Examples of such blowing agents are inorganic blowing agents, in particular carbon dioxide. Use of inorganic blowing agents, and in particular carbon dioxide, is preferred because they are considered to be more environmentally safe compared to traditional blowing agents.

5

CARBON DIOXIDE BLOWING AGENT

In a preferred embodiment of this invention, the blowing agent utilized contains a major amount of carbon dioxide. In one embodiment, the amount of the blowing agent added to make the foamable gel is from about 1% to about 16% by weight based on the 10 weight of the polymer. In another embodiment, the amount of the blowing agent added to make the foamable gel is from about 2% to about 15% by weight based on the weight of the polymer. In yet another embodiment, the amount of the blowing agent added to the foamable gel is from about 3% to about 10% by weight based on the weight of the polymer. In a preferred embodiment, the amount of the blowing agent added to the 15 foamable gel is from about 4% to about 8% by weight based on the weight of the polymer. Variations in the amount of blowing agent incorporated into the foamable gel may be utilized, depending in part on the components of the blowing agent mixtures, to prepare extruded foam products having different desirable characteristics.

A major amount of carbon dioxide means that the blowing agent contains more 20 than 50% by weight carbon dioxide. In one embodiment, the blowing agent contains more than about 60% carbon dioxide, and particularly from 65-100% of carbon dioxide. In another embodiment, the blowing agent contains from 70-90% of carbon dioxide. In yet another embodiment, the blowing agent may be about 100% of carbon dioxide.

The blowing agent may be a mixture of carbon dioxide and at least one lower 25 alcohol. A lower alcohol is an alkyl alcohol containing from 1 to about 4 carbon atoms. Lower alcohols include methanol, ethanol, propanol, isopropanol and butanol. The above carbon dioxide and blowing agent mixtures may also be used with additional, optional and supplemental blowing agents, most notably air, nitrogen and water as described below.

30 Particularly useful mixtures of blowing agents include mixtures comprising: 51-90% of carbon dioxide and 10-49% of ethanol; 60-80% of carbon dioxide and 20-40% of ethanol; 51-90% of carbon dioxide and 10-49% of methanol; 60-80% of carbon dioxide and 20-40% of methanol; 51-90% of carbon dioxide and 10-49% of water; and 60-80% of

carbon dioxide and 20-40% of water. The optional use of a lower alcohol in combination with carbon dioxide provides extruded foam products or bodies having larger cell sizes (from about 1% to about 25% larger in size) when compared to similar density bodies produced with carbon dioxide without a lower alcohol. Additionally, the blowing agent blends including carbon dioxide may contribute to extruded foam products or bodies having improved compressive strengths at comparable densities. Extruded foam products of acceptable characteristics are obtained utilizing the above blowing agent and blowing agent mixtures, and there is no necessity to use halo-carbon blowing agents.

In a preferred embodiment, the blowing agent is free of halogen blowing agents. Halogen blowing agents include halo-carbons such as chlorofluorocarbons, fluorocarbons, soft chlorofluorocarbons, fluorohydrocarbons, and chlorofluorohydrocarbons (typically of methane and ethane). Specific examples of halogen blowing agents include methylchloride, ethylchloride, chlorotrifluoromethane, dichlorodifluoromethane, 1,2,2-trifluoro-1,1,2-tri-chloroethane, chlorodifluoromethane, 1,1-dichloro-2,2,2-trifluoroethane, 1-chloro-1,1-difluoroethane, 1,1,1,2-tetrafluoroethane and 1,1-di-chloro-1-fluoroethane among others. Since halogen blowing agents can be harmful to the environment, their use is not desirable.

The blowing agent including blowing agent mixtures utilized in the process may be added to make the foamable gels in any conventional manner. The blowing agent can be incorporated to make the foamable gel before, during or after polymerization of the polymer used to make the foamable gel. In one embodiment, the foamable gel is made by directly injecting the blowing agent into a heat plastifying and mixing apparatus, such as an extruder, which contains a plastified resin mixture. When more than one blowing agent is to be utilized, each of the blowing agents may be separately injected into the heat plastifying and mixing apparatus.

CELL SHAPE

The extruded foam products of this invention have a x-axis, y-axis, and z-axis as defined herein. The x-axis is the direction in which the foam product was extruded during the manufacturing process. The x-axis is also called the extrusion direction. The y-axis is perpendicular and shares the same plane as the extrusion direction. The y-axis is also called the horizontal direction. The z-axis is perpendicular to both the horizontal and extrusion direction. The z-axis is also called the vertical direction.

Owing to the manner in which the blowing agent escapes during an extruded foam manufacturing process, the cells within the foam are often oblong shaped along the direction of the z-axis. This oblong shape may be quantified by measuring the x:z orientation. The x:z orientation is defined as the average cell size in the x-axis divided by the average cell size in the z-axis. The average cell size in the x-axis and the z-axis is determined by ASTM D3576-94.

The extruded foam products comprising titanium dioxide and talc of this invention have a x:z orientation closer to 1.0 when compared to that of a corresponding foam without the titanium dioxide and/or talc. A corresponding foam is a foam of a similar polymer material composition and density.

EXTRUDED FOAM PRODUCT PROPERTIES

The extruded foam products prepared in accordance with the invention are characterized generally as having the following characteristics.

The resultant extruded foam products generally have a relatively low density, typically less than about 3.75 lbs/ft³ (60.0 kg/m³). Density can be determined, for example, in accordance with ASTM D1622-88. In one embodiment, the extruded foam products have a density from 0.100 – 3.75 lbs/ft³ (1.60 – 60.0 kg/m³). In another embodiment, the extruded foam products have a density from 0.5 – 3.68 lbs/ft³ (8.00 – 59.0 kg/m³). In a preferred embodiment, the extruded foam products have a density from 1 – 3.62 lbs/ft³ (16.0 – 58.0 kg/m³). In a more preferred embodiment, the extruded foam products have a density from 1.5 – 3.56 lbs/ft³ (24.0 – 57.0 kg/m³).

The resultant extruded foam products generally have a relatively small average cell size, typically less than about 0.4 mm. Average cell size can be determined, for example, according to ASTM D3576-77. In one embodiment, the extruded foam products have an average cell size from about 0.01 mm to about 0.4 mm. In another embodiment, the extruded foam products have an average cell size from about 0.05 mm to about 0.35 mm. In a preferred embodiment, the extruded foam products have an average cell size from about 0.1 mm to about 0.3 mm. In a more preferred embodiment, the extruded foam products have an average cell size from about 0.15 mm to about 0.25 mm.

The resultant extruded foam products generally have a relatively uniform average cell size, typically more than about 50% of the cells have a size within about 0.06 mm of the average cell size. In one embodiment, more than about 60% of the cells have a size

within about 0.06 mm of the average cell size. In another embodiment, more than about 50% of the cells have a size within about 0.05 mm of the average cell size. In yet another embodiment, more than about 50% of the cells have a size within about 0.045 mm of the average cell size.

5 The resultant extruded foam products generally contain a major amount of closed cells and a minor amount of open cells. The relative amount of closed cells can be determined, for example, according to ASTM D2856-A. In one embodiment, more than about 70% of the cells of the resultant extruded foam products are closed cells. In another embodiment, more than about 80% of the cells of the resultant extruded foam products 10 are closed cells. In a preferred embodiment, more than about 90% of the cells of the resultant extruded foam products are closed cells. In a more preferred embodiment, more than about 95% of the cells of the resultant extruded foam products are closed cells.

In one embodiment, the resultant extruded foam products made in accordance with the present invention have dimensional stability in any direction of about 5% or less. In 15 another embodiment, the resultant extruded foam products made in accordance with the present invention have dimensional stability in any direction of about 4% or less. In a preferred embodiment, the resultant extruded foam products made in accordance with the present invention have dimensional stability in any direction of about 3% or less. In a more preferred embodiment, the resultant extruded foam products made in accordance 20 with the present invention have dimensional stability in any direction of about 2% or less.

The extruded foam products of this invention may be fashioned into an insulating panel which may be used to insulate a surface by applying the panel to the surface. Such panel is useful in any conventional insulating applications such as roofing, buildings, refrigerators, etc.

25 The following are examples of the present invention, and are not to be construed as limiting.

Example

A resinous mixture was fed to a co-rotating twin screw extruder at a rate of 169 30 kg/hr along with 2.65 kg/hr of flame retardant. The resinous mixture comprised a polystyrene polymer, titanium dioxide at 2.0 wt. %, and talc at 1.2 wt. % based on the polymer. The mixture was melted in the extruder and mixed with 95 grams per minute of carbon dioxide and 17 grams per minute of ethanol. The resulting foamable gel was then

cooled and foamed into a region of lower pressure producing a 61 mm thick by 760 mm wide product, with a density of 51.2 kg/m³, with an x:z orientation of 1.0.

Comparative Example

5 A resinous mixture was fed to a co-rotating twin screw extruder at a rate of 169 kg/hr, along with 2.65 kg/hr of flame retardant. The resinous mixture comprised a polystyrene polymer and talc at 1.2 wt. % based on the polymer. The mixture was melted in the extruder and mixed with 95 grams per minute of carbon dioxide and 17 grams per minute of ethanol. The resulting foamable gel was then cooled and foamed into a region of lower
10 pressure producing a 61.2 mm thick by 760 mm wide product, with a density of 52.8 kg/m³, with an x:z orientation of 0.9.

While the invention has been explained in detail and in relation to its preferred embodiments, it is to be understood that various modifications thereof will become apparent to those skilled in the art upon reading the specification. Therefore, it is to be
15 understood that the invention disclosed herein is intended to cover such modifications as fall within the scope of the appended claims.

WHAT IS CLAIMED IS:

1. A process for making an extruded polymer foam comprising:
 - a) heating to a first temperature, a resin mixture comprising polymer, titanium dioxide, talc, and optional additives;
 - b) incorporating one or more blowing agents into the resin mixture under a first pressure to make a gel, said pressure is sufficient to prevent foaming of the gel;
 - c) cooling the gel to a second temperature; and
 - d) extruding the gel through a die to a region of lower second pressure to form the foam.
- 15 2. The process of claim 1 wherein the first temperature is from 135°C-240°C (275°F-464°F).
3. The process of claim 1 wherein the first pressure is from 4.826 – 41.36 mPa.
4. The process of claim 1 wherein the process is free of halogen blowing agents.
- 20 5. The process of claim 4 wherein the blowing agent contains a major amount of carbon dioxide.
6. The process of claim 1 wherein the second temperature is from 140°C-105°C (284°F-221°F).
- 25 7. The process of claim 1 wherein the second pressure is from 0 – 193 kPa.
8. The process of claim 1 wherein titanium dioxide is added in an amount of 0.1 to 5.0 wt. % of the polymer and talc is added in an amount of 0.1 to 5.0 wt. % of the polymer.
- 30

9. The process of claim 1 wherein titanium dioxide is added in an amount of 0.2 to 4.0 wt. % of the polymer and talc is added in an amount of 0.2 to 4.0 wt. % of the polymer.
- 5 10. The process of claim 1 wherein titanium dioxide is added in an amount of 0.5 to 2.5 wt. % of the polymer and talc is added in an amount of 0.5 to 2.5 wt. % of the polymer.
11. An extruded foam product comprising a polymer, titanium dioxide, and talc; wherein the product has a x:z orientation greater than 0.90.
- 10 12. The product of claim 11 wherein the x:z orientation is greater than 0.95.
13. The product of claim 11 wherein titanium dioxide is present in an amount of 0.1 to 5.0 wt. % of the polymer and talc is added in an amount of 0.1 to 5.0 wt. % of the polymer.
- 15 14. The product of claim 11 wherein titanium dioxide is present in an amount of 0.2 to 4.0 wt. % of the polymer and talc is added in an amount of 0.2 to 4.0 wt. % of the polymer.
- 20 15. The product of claim 11 wherein titanium dioxide is present in an amount of 0.5 to 2.5 wt. % of the polymer and talc is added in an amount of 0.5 to 2.5 wt. % of the polymer.
16. The product of claim 11 wherein the polymer comprises polystyrene.
- 25 17. An extruded foam product comprising a polystyrene polymer having a x:z orientation greater than 0.95.
18. The product of claim 17 wherein the x:z orientation is about 1.0.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/31148

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 C08J9/00 B29C44/34 C08J9/12 //C08L25/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C08J B29C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 710 186 A (CHAUDHARY BHARAT I) 20 January 1998 (1998-01-20)	1-7
A	example 1 claims	8-18
A	US 4 544 677 A (ALLEN RICHARD B ET AL) 1 October 1985 (1985-10-01) column 2, line 28-32 table 7 claims	1-18

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

& document member of the same patent family

Date of the actual completion of the international search

26 March 2001

Date of mailing of the international search report

03/04/2001

Name and mailing address of the ISA
European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Oudot, R

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 00/31148

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US 5710186	A 20-01-1998	AU 3144997 A	WO 9745478 A	05-01-1998 04-12-1997
US 4544677	A 01-10-1985	CA 1250087 A	EP 0158266 A	14-02-1989 16-10-1985